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ANNUAL REPORT OF THE COFFEE SCIENTIFIC OFFICER, 1933-34

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ANNUAL REPORT OF THE COFFEE SCIENTIFIC OFFICER, 1933-34.

I have the honour to present the Administration Report of the Coffee Scientific Officer for the year ending 31st March 1934, dealing with work in progress in connection with coffee problems.

As in previous years, the work has been centred at the Mysore Government Coffee Experiment Station, Balehonnur, under the direction of Dr. L. C. Coleman. Work in co-operation with the officers of the Station has been continued in connection with breeding, spraying and miscellaneous problems.

The Scientific Officer was on home leave from April 10th to October 8th, during which period the Assistant carried on routine work at Balehonnur. From November, the Assistant returned to Sidapur and was at work there for the remainder of the year.

Working conditions at Sidapur have been improved by alterations in the old building, the provision of bigger windows and a water supply for laboratory purposes.

The report comprises, as usual, a short account of touring work, scientific investigations in progress and general notes on coffee problems which have been raised during the year.

Touring.

The Assistant visited Coorg in July in connection with the field work on Eelworm, followed by a second visit in September for the same purpose. The work of these visits will be dealt with later in the report. A visit to an estate in the Bababudans in August led to the discovery of parasitic eelworms in an area of coffee where supply failure has been very high.

In response to an urgent enquiry from the Anamalais, the Assistant paid a visit to the district in August to report on serious damage to coffee suspected of being due to spray injury by Burgundy mixture. At the time of the visit, it was practically impossible to decide what was the

actual cause of the leaf fall as by the time the visit was made the situation was complicated by the presence of some leaf fall due to Leaf Disease and Die Back. From a consideration of the climatic conditions obtaining at the period when damage was greatest, it is possible that the heavy leaf fall was the consequence of spray injury, not on account of any defect in the preparation of the mixture, but due to a normal Burgundy spray carried out in moist weather. Spray damage is often very capricious in its appearance and the requisite conditions for its appearance may not often occur, but Burgundy is generally recognized as a less safe spray than Bordeaux and if conditions are favourable for spray injury, it is more likely to appear with the former. Studies on spray injury with copper containing sprays in other countries have shown that moist weather during the spraying period is often a predisposing factor.

The Scientific Officer visited Sidapur during November to arrange further work on the Eelworm problem.

Investigations.

Leaf Disease—Progress Report.—It is regrettable that progress in the work on the inheritance of resistance and the study of the behaviour of the Station selections to Leaf Disease strains has been held up. A good deal of difficulty has been experienced with the stock cultures, particularly during the dry season and the accidental loss of one pure strain at a period when the re-establishment of cultures was most difficult completely held up further work.

More satisfactory means of housing cultures and carrying out a large number of tests at a time are in preparation and there is every hope of substantial progress during the coming year.

Die Back—Progress Report.—The monsoon of 1933 was marked by very severe attacks of Die Back in a great many estates both in Mysore and elsewhere and both sprayed and unsprayed areas suffered in consequence. It was not possible to take up work until October but a visit was paid to several affected estates in early October and this, with a study of the data collected in connection with crop losses and spray mixtures help to throw a little light on the circumstances leading up to the attack.

The severity of the attack is clear from the following figures obtained from the observations carried out in the time and strength of spray mixtures experiment in 1932 and 1933:—

TABLE I.

Percentage Die Back in September 1932 and 1933.

	Per cent 1932	*Per cent* 1933
0·5 Pre and Post monsoon spray ...	3·1	8·7
Control. Unsprayed	8·8	23·5

It can be seen that Die Back was three times as severe in 1933 as it was in 1932 in this area, though it was not an area that suffered as severely as many others, even in 1933. It is also clear that as far as this area is concerned, spraying did exert a protective influence as in each year the amount of Die Back in the controls was just under three times as much as in the sprayed plots. In some other areas, however, the degree of control was not as great as this and sprayed areas seemed to suffer as severely as others. In association with Mr. M. J. Narasimhan, the Mysore Government Mycologist, and Mr. K. H. Srinivasan, Assistant Director of Agriculture, Chikmagalur, a short note was published indicating the conditions which appeared to be the main predisposing causes. The main point of importance was that the theory put forward formerly that Die Back was a consequence of defoliation by Leaf Disease needed considerable modification in the light of experience in 1933. During this year, there was no lack of evidence that the onset of Die Back was not necessarily preceded by defoliation, as shoots were frequently found in which shoot decay had commenced when a number of pairs of healthy leaves up to the apical bud were present. In view of this, it appeared necessary to make a more accurate study of the part played by the fungus constantly found in Die Back shoots.

A number of isolations made in November gave a series of cultures of *Colletotrichum coffeanum*. This is in agreement with cultural work done in previous years when this fungus occurred in practically all isolations attempted. At the same time, isolations were also made from leaves of coffee suffering from Brown Blight, with which the same fungus, or a strain of it, is associated. In view

of the possibility that there may occur especially virulent strains of this fungus, it was decided that a study of a large number of isolations from coffee shoots and Brown Blight affected leaves was desirable.

The cultural work showed that the fungus is an extremely variable one, both in regard to its vegetative characters in culture and to its ability to form asexual spores (conidia) and the perfect *Glomerella* stage. Furthermore, cultures were found to be very unstable in regard to these characters, and sometimes gave rise to variants without apparent cause. This instability of type in this fungus has already been commented upon by Small in his work on the genus *Colletotrichum*.

The variation in ability to form the perfect stage, which is characterized by the production of a second spore form—the ascospore—is of particular interest because cases are known of differences in infective capacity of the different spore forms.

Up to the end of the year, no inoculation experiments were possible owing to the absence of suitable material. These are to be taken up as soon as the hot weather growth gives ample supplies of young shoot. Further work is planned to study the strains of the fungus, to test the infective capacity of both forms of spores and to establish satisfactory inoculation experiments.

It may be remarked in this connection, that a study of scorched leaves and shoots from Robusta plants suffering from drought during March also showed the presence of *Colletotrichum* among other fungi. It is clear that this fungus is very common on any portions of coffee plants which are weakened or damaged in any way.

Studies on Spray Mixtures.—The leaf count method of studying the relative value of different adhesives and mixtures was followed as in previous years. The extent and severity of the disease attack in this series of plots was very great and the leaf retention at the end of September was roughly half that obtained in previous years. Two new treatments were included, one employing Gingelly oil as an adhesive with Bordeaux and the other, a proprietary colloidal copper spray known as Bouisol. These took the place of plots formerly sprayed with Linseed Bordeaux at a strength of 20 and 40 ozs. The results for the year are given in the accompanying table.

Previous years results will be found in earlier reports and in the bulletin on spraying (Sta. Bul. No. 9).

TABLE II.

Leaf Amount and Percentage Infection in Plots receiving different types of Spray, 1933.

	Leaf Amount	Percentage Infection
Gingelly Oil Bordeaux	3·66±·16	44·1
Bordeaux without Ad.	3·56±·25	43·9
Casein Bordeaux	3·50±·25	43·9
Fish Oil Burgundy	3·37±·32	53·6
Alum Bordeaux	3·31±·27	54·0
Resin Soda Burgundy	3·27±·21	54·4
Linseed Bordeaux	3·23±·24	50·4
Burgundy without Ad.	2·80±·18	58·5
Resin Soda Bordeaux	2·75±·20	53·4
Bouisol	1·97±·14	46·8
Control unsprayed	1·72±·14	51·1

The first seven sprays in the above list show no real difference from Casein Bordeaux, while the remainder are definitely poorer in the protection they have afforded. It is interesting to note the lower percentage infection in the first three spays. A similar phenomena was observed last year when, on the basis of percentage infection data, the sprays were divided into two groups, one containing Casein, Linseed, Resin Soda Bordeaux and Bordeaux without adhesive and the other Alum Bordeaux Resin Soda Burgundy, Fish Oil Burgundy and No Adhesive Burgundy. Resin Soda Bordeaux and Linseed Bordeaux are not in the first class in 1933. The results are given in the table arranged according to percentage infection.

TABLE III.

Percentage Infection data for 1932 and 1933.

—	1932	1933
	Per cent	Per cent
GROUP I.		
Gingelly Oil Bordeaux	...	44·1
Bordeaux without Adhesive ...	9·5	43·9
Casein Bordeaux	10·4	43·9
Linseed Bordeaux	14·1	(50·4)
Resin Soda Bordeaux	14·1	(53·4)
GROUP II.		
Resin Soda Burgundy	21·7	54·4
No adhesive Burgundy	19·6	58·5
Fish Oil Resin Soap Burg	22·3	53·6
Alum Bordeaux	24·7	54·0

The results are not so clear cut in the earlier years though Alum Bordeaux has always shown a markedly higher percentage infection than the remainder and Resin Soda Burgundy a slightly higher one than the Bordeaux sprays in the first group given in the table.

The results from Gingelly Oil are encouraging but a warning must be given that the plots receiving this spray were not strictly comparable with the others as, owing to the omission of one application in 1932, they suffered a much severer attack of the disease in the latter part of 1932. In consequence, they were probably freer of old disease pustules in early 1933 and consequently in a slightly more favourable position than the other plots.

So far, the results favour Bordeaux mixture with Casein or Linseed Oil or perhaps some other vegetable oil such as Gingelly, but it must be admitted that the absence of an adhesive does not seem to result in a very great reduction of effectiveness. Even in a year of severe disease, Bordeaux without an adhesive has done very well.

It may be pointed out here that though the term "adhesive" has been used in this discussion and in previous discussions of the subject, the use of this term

does not serve to define the actual behaviour of the addition made to the spray mixture. It is probable that the action may be the improvement of the spreading powers of the mixture as well as in improving the adhesive qualities.

Time and Strength of Spray Studies.—These studies have been carried out as in previous years and the results are given in the accompanying table. As can be seen, this area did not suffer as severely as the area under different spray mixtures and the leaf retention is much the same as in previous years.

TABLE IV.

Leaf Amount and Percentage Infection in Time and Strength of Spray Plots.

Treatment	September 1933		February 1934	
	Leaf Amount	Percentage Infection	Leaf Amount	Percentage Infection
Control I	2.40±·15	42·3	3·02±·14	41·1
1 per cent May and September.	4·06±·21	43·2	3·83±·16	26·3
Control II	2·92± 17	58.9	2·54±·13	39·5
1 per cent May only ...	6·01±·21	46·1	2·63±·14	33·6
Control III	3·30±·20	51·0	2·40±·13	35·0
·5 per cent May and September.	6·36±·25	53·1	3·31±·13	32·6
Control IV	3·19± 17	53·1	2·32±·11	42·3
·5 May only	6·25±·27	57·7	2·76±·14	25·5
Control V	2·95±·19	43·9	3·17±·14	39·0
1 per cent Sept. only ...	2·81±·20	37·3	3·95±·16	21·5
Control VI	2·84±·19	49·6	2·89±·12	28·3
·5 per cent Sept. only ...	2·97±·20	50·7	3·48±·14	27·4
Control VII	3·23±·22	53·2	2·63±·13	35·6

On the whole, the results resemble very closely those of previous years, though the area receiving the one per cent spray in both May and September is poorer than would have been expected. This is probably due to the uneven intensity of the disease, which is indicated also by the rise in the leaf amount in the Control plots from the first to the third and fourth at the September observations. After making allowance for this, there is no real difference in any of the plots between the two strengths of spray and thus, results confirm previous work.

The value of the second spray is well illustrated in this year's data by the figures for leaf retention obtained at the end of February. The areas receiving a spray in

May only show leaf amounts of 2·65 and 2·76, while those receiving sprays in May and September give 3·83 and 3·31, differences which are definitely significant. At the same time, the areas sprayed only in September show a bigger retention of leaf than the Controls.

The course of results in this experiment has been very regular for the whole period and the main conclusions as to the time and strength of the spray which give best results coupled with economy are well established for areas of a type of climate similar to that of the Experiment Station.

Interest now centres more on the Control plots which give data enabling an estimate of the intensity of the disease from year to year in this area to be made. The detailed working out of these data will require several more years' observations but it is of interest to examine the results of the last two years. For ease of discussion, the mean values of leaf amount and percentage infection for all seven Control plots taken together are given in table V.

TABLE V.

Leaf Amount and Percentage Infection in 1932–33 and 1933–34 in Unsprayed Plots.

—	Leaf Amount	Percentage Infection
		Per cent
September 1932	4·48	67·8
February 1933	2·48	24·5
September 1933	2·98	50·3
February 1934	2·71	34·4

Thus, in 1933, there was very considerably less leaf on the trees in September than in 1932. The difference is slightly reduced if allowance is made for the greater amount of Die Back in 1933 but it is still quite definite. This indicates very clearly the severity of the disease in the period prior to September in 1933. There was approximately 50 per cent more leaf present on the trees at the same date in 1932, as indicated by the observations on typical branch systems.

By February 1934, the amount of leaf was approximately the same as in 1933, indicating that the balance between leaf loss and leaf production between October and February favoured leaf production more than the corresponding period in 1932-33. It is impossible to say whether the difference is due to less intensity of disease or to greater production of leaf in 1953-34 during these months. The probability is that, following the very severe disease in the monsoon period of 1933, the development of the disease in the latter part of the year was somewhat delayed. It was noticeable that during October the disease situation was not severe though of course the leaf amount on the trees was low. This suggestion is further supported by the higher percentage infection in February 1934 than at the corresponding period in 1933. This may be taken to indicate that the disease in the latter part of 1933 and early 1934 was later in developing leading to a relatively greater amount of leaf but a higher percentage of diseased leaf.

The utility of these analyses of results from year to year is to build up a body of evidence on the seasonal behaviour of the disease which can be related to the climate and utilized for the forecasting of the disease situation and for more accurate timing of sprays. The importance attached to correct timing of sprays in the control of fruit diseases in temperate climates is a clear indication of the value of this work. Moreover, the extensive complaints of poor results in 1933 from spraying indicate that we are still a long way from the best utilization of spraying in the control of Leaf Disease.

Both the data so far collected and general observations tend to indicate that the weather conditions between January and the beginning of the monsoon are of the greatest importance in determining the severity likely to be attained by Leaf Disease in the latter half of the year. This conclusion was first suggested in 1931 as a result of detailed observations and the work done since amply confirms this view. Further, the amount of diseased leaf carried into the dry season is a second factor of great importance.

Flower and Fruit Studies

Crop Losses during Development.—The observations on the crop losses during development were carried out as

usual during 1933. This was an especially interesting year in that blossom showers fell in February and the data were expected to throw some light on the effect of the early showers on the setting. The data obtained on this question are given in Table VI, together with the similar data for the two previous years.

TABLE VI.

Loss of Developing Fruit during Development.

	1931		1932		1933	
		Per cent.		Per cent.		Per cent.
Original Flower Bud ...	9,031	...	5,379	...	6,768	...
Loss 1. First 4 weeks ...	1,850	20·5	1,411	26·2	1,823	26·9
Loss 2. 5th–11th week ...	3,403	38·3	1,501	27·9	1,801	26·6
Loss 3. 11th week to crop ...	381	4·2	241	4·5	533	7·9
Crop harvested	3,397	37·6	2,226	41·4	2,611	38·6

The data have been divided into three groups, comprising the first four weeks, the fifth to eleventh weeks and the remainder of the developing period. These groups were determined in 1931, when it was found that until the fourth week it was impossible to be sure whether all the fruit initials had set, but by the fifth week, the set fruit could be differentiated by their size from unset fruit initials which sometimes persist until the end of the year. The second period was defined by the completion of the very marked loss which occurs roughly about the eleventh week. It is distinguished by the falling of a number of partly swollen fruit which otherwise appear healthy externally. These time groupings have been adhered to as it has not yet been possible to carry out the detailed examination of the records week by week.

The main points of interest in 1933 are the similar final percentage set to that obtained in previous years and the rather higher loss in the latter part of the year. The early showers do not seem to have affected the amount of fruit set or the times at which the main losses occurred, though it is admitted that the grouping employed is a very broad one and might well conceal small variations in time of loss. The slightly greater loss in the latter part of the year is probably to be attributed to disease playing a bigger part than usual in causing leaf fall and die back. Of the hundred cropping shoots under observation, 34 had shown symptoms of dying back from

the tips in 1933, while in 1932, only one out of a hundred such shoots showed similar symptoms. The surprising fact is that the later loss was not much larger.

It must be remembered that though this loss is only a relatively small percentage of the original bud, it is a much larger proportion of the final crop. The actual loss appears greater when it is realized that the loss in the latter part of the year was twice as great in 1933 as it was in 1932, and in the latter year this loss was equivalent to 10 per cent of the crop harvested.

The results indicate that on the whole the percentage of the blossom forming ripe fruit does not vary greatly from year to year and that the greater part of the loss occurs in the first three months after blossom. As far as the 1933 evidence is concerned, a blossom shower as early as the end of February sets as well as one in early April. It must be remembered, however, that in 1933 the February rains were not followed by any extended dry period as is frequently the case with early blossom showers.

On the whole, the early losses are probably unavoidable and are to be attributed to failure to fertilise and to competition for food materials. It is to be noted that the second period of loss indicated above coincides with the period when the fruit is increasing most rapidly in size.

Examination of the Crop Picked.—The crop harvested from the branches under observation was examined as in previous years and the data analysed. The results are given in Table VII.

TABLE VII.

Analysis of Fruit Picked in Crop Development Observations.

	1931	1932	1933
Total Fruit	3,397	2,226	2,611
Per cent Peaberry ...	13·3 per cent	21·5 per cent	12·1 per cent
Per cent 3 Bean Cherries ...	1·0 ,,	1·0 ,,	1·0 ,,
Total Number of Beans ...	6,376	4,001	4,874
Per cent Empty Beans ...	2·0 per cent	2·3 per cent	1·7 per cent
Per cent Black Beans ...	11·9 ,,	0·3 ,,	17·0 ,,

It can be seen at once that 1933 was a bad Black Bean year, at least as far as the Experiment Station is concerned. Reports of it from elsewhere were also

received. In other respects, the figures call for little remark; three bean cherries and empty beans seem to occur in about the same proportion each year.

A detailed examination of the climate in 1931 and 1933 remains to be made to see if there are any points of correspondence. A cursory examination of the records does not suggest any obvious feature in common. On the meagre data at present available, it is impossible to discuss the relation of Black Bean to climatic conditions. A closer study of the affected beans themselves was taken up and will be considered below.

As in 1931, samples of fruit from plots receiving different manurial treatment were cut open, and the amount of Black Bean determined. The results are given in Table VIII.

In this case, the different treatments seemed to have exerted no influence whatever on the amount of Black Bean, contrary to the indications in 1931.

TABLE VIII.

Effect of Manuring on Amount of Black Bean.

	N.	P.	K.	N. P. K.	Control
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1931	11·3	4·9	4·1	6·3	5·4
1933	19·5	20·0	17·5	20·0	19·0

It must be pointed out that these figures represent the percentage of affected fruit and not percentage of affected beans as given in Table VII. Again, the samples taken were small, about 200 fruit from each plot being examined.

Laboratory Study of Black Bean and Related Problems. Although previous work had given negative results in the search for a parasitic organism, further work was taken up especially as the affection had many points of correspondence with the Coffee Bean Disease found in East Africa which is associated with a parasitic yeast.

The results of this work confirmed that of previous studies. In one series of 22 cultures, only four showed any development of organisms of which three were bacteria mixed with a yeast and the fourth an unidentified

fungus mycelium. The yeast was not at all similar to the parasitic type. Another series of 26 cultures made in a similar way gave 16 cultures with no growth, four with *Penicillium* which was obviously a contamination, five with an unidentified fungus mycelium and one with bacteria. Further, the microscopic examination of a great deal of rotted bean material failed to reveal any signs of an organism.

At the same time, attention was paid to the anatomy of affected beans and this threw a good deal of light on the problem and confirmed the opinion that the trouble is not the consequence of any parasitic invasion.

In some respects the Black Bean seemed to differ from that described in 1931. On the whole, the rotting was not wet as in that year, when affected beans seemed to contain a soft brown material in place of the hard white endosperm tissue. In 1933, the endosperm tissue was much reduced in volume and composed of collapsed thin walled cells which were empty of contents instead of being thick walled as in normal beans. The split in which the young embryo lies was large and empty except for the embryo which was usually quite normal in appearance. The whole bean was shrunken away from the parchment and into the spaces, curious swollen cells protruding from the silver skin were found. In the course of cultural work in which pieces of affected bean were placed on agar, these cells were found to proliferate and give rise to quite a quantity of gelatinous cells, visible as a glistening velvety looking tissue. These cells were not present in every case examined but they were met with quite frequently.

Further, immediately underlying the silver skin a layer of tissue composed of thin walled cells intervened before reaching the large collapsed cells of the decayed endosperm. The large swollen cells noted above appeared to arise from this and force their way through the silver skin.

Attention was directed at the same time to spotted beans, of which large numbers were present in the crop of 1933. An examination of a large numbers of these led to the conclusion that the spotting was of the same nature as the Black Bean as all stages between a complete Black Bean and a mere spot on the surface of the bean could be found. Accordingly more attention was paid to spotted beans in the later work as likely to throw more light on

the origin of the trouble than beans in which the changes had been completed.

In the case of a slightly spotted bean, the chief characteristics were the presence of a definite tissue of small cells lying under the silver skin over the area of the spot, a layer of brown disorganized tissue in the endosperm, surrounded by more or less normal endosperm cells, which appear, however, to contain more cell contents than are present in cells further removed from the spot. In more severely attacked beans, the brown discoloured and disorganized tissue becomes a layer in the endosperm, bounded on the inside by almost normal cells and on the outside by large collapsed empty, thin walled cells. In completely decayed beans this brown layer lines the embryonic cavity.

The spots are usually on the outer surface of the beans but not always and it sometimes happens that a spot on the outer surface has a spot on the inner fold of the bean immediately beneath. Once or twice, an apparently quite healthy bean has shown a small brown spot inside the fold when it was dissected; this is apparently not frequent, though of course it might frequently be missed, even when the bean is cut open.

Finally, in relatively small spots, the brown disorganized tissues can be seen as a mass of material apparently forcing its way between the normal endosperm cells, but the endosperm cells are so arranged with respect to the disorganized tissue that it is evident that they were formed after a focus of some activity had arisen in the place occupied by the disorganized tissue. This seems to be a point of the first importance, as timing the date of origin of the affection.

The anatomical studies thus led to the conclusion that Black Bean and spotted beans were of the same nature. The question then presented itself as to whether the latter was a stage in the development of the former or whether they represent a difference in the degree of affection. In other words were spots developing continuously to involve more and more bean tissue or were they stationary at the time of crop, and a spotted bean unable to develop into a completely affected bean? This could not be examined directly but an attempt was made to see if any increase in size could be observed if affected beans were kept in a moist condition. A number of spotted

beans in the parchment were surface sterilized and placed in tubes of sterile distilled water, after the area of the spots had been determined. At weekly intervals for five weeks a number of beans were taken and again measured. In no case was any increase in size noted as far as that could be determined by superficial measurement. This result suggests, though it is not conclusive, that the spots are not developing in ripe fruit.

A great deal of cultural work was done with spotted beans and at first very confusing results were obtained. Cultures made from parchment containing spotted beans which was collected from the drying table always gave growth in culture in which one or two species of yeast predominated. Further work showed, however, that identical cultures were obtained from similar parchment which had no spots, indicating that these organisms had no relation to the spotting. It was then found that parchment collected in the field and cleaned chemically gave no growth in culture, and consequently it was concluded that organisms penetrate inside the parchment during fermentation. These results will be further considered below.

In view of the cultural results with unspotted beans, it was clear that the spotting was not due to any of the organisms found in the earlier cultural work.

Finally tests were made on the ability of spotted beans to germinate. In these tests, spotted beans gave from 76 per cent to 86 per cent germination and even beans in which quite half the bean was blackened gave 30 per cent germination.

A full discussion of the significance of this work must await a further publication as it requires a preliminary account of the anatomy of the coffee bean which would be out of place in this report. The main conclusions which the work provides are as follows:—

(1) Black Bean and spotted beans are of the same essential nature and are accompanied by definite anatomical features.

(2) The trouble is dated by the fact that the arrangement of normal endosperm cells around a spot indicates that a focus of activity of some sort existed before the final endosperm cells were laid down. This occurs sometime about early August.

(3) The trouble is almost certainly a nutritive abnormality. The persistence of the small celled layer between the silver skin and the endosperm and the tendency of this layer to proliferate is a support to this view. Early workers on coffee bean anatomy designated this layer, the nutritive layer, and noted that it normally disappeared at maturity.

(4) The trouble is not caused by a parasitic organism. This is shown by the absence of results from the cultural work and is further supported by the germinability of spotted beans and the stability of the spots once the endosperm is formed.

While it is still not possible to designate the actual cause of this trouble or the conditions which give rise to it, the year has shown substantial progress in the study of the subject. The physiological nature of the affection is now firmly established and the time of origin is clearly indicated.

The Fermentation of Coffee.—As has already been briefly mentioned, the study of spotted bean led to the attempt being made to obtain cultures from parchment which had been fermented and washed. With the most careful sterilization of the outside of the parchment, cultures taken under aseptic conditions from the interior of the parchment—usually in the form of scrapings or small fragments of the bean—gave very regular cultures of a group of organisms, the principal members of which were yeasts. Parallel cultures carried out in exactly the same way but taken from parchment collected directly from the field and cleaned chemically remained sterile. It was also proved that chemical cleaning did not interfere with organisms if present inside the parchment.

These results indicate clearly that during the normal process of fermentation, organisms penetrate into the space between the bean and the parchment. This penetration must occur through the cleft on the flat side of the parchment as it is only here that a break occurs in the continuity of the parchment. The number of organisms found are relatively few in variety, the principal one being a yeast. There are also some bacteria and one or two other organisms not yet identified but which suggest the genus. *Endomyces.*

Similar organisms were regularly recovered from the first washing water. Further investigation revealed that

coffee dried ready for transport to the coast also gave positive results when cultures were made from it. The ordinary degree of drying before transport to the coast is therefore not sufficient to destory these organisms.

Work this year could not proceed further than the establishment of the presence of the organisms. The results open a wide field of investigation as the presence of yeasts and bacteria within the parchment raises the part played by fermentation in the preparation of coffee to a more important level than the mere removal of the "saccharine matter" after pulping. Further work on the question is planned for the next crop season.

Nematode Worms and Death of Supplies.—The Assistant Scientific Officer has been concerned almost exclusively with investigations on this problem and on developing methods of studying the Nematode worms which the work done in 1932 indicated as the most likely cause of the failure of supplies. During the period he was stationed at Balehonnur, work was concentrated on the study of methods of isolating worms from the soil and some experiments were attempted to study the effect of mutilating roots on the regeneration of new root tips. Finally some inoculation experiments were made on plants planted in root inspection boxes. During this period some manuring experiments were started in Coorg along the lines of experiments tried in Java to see if forcing the plants to grow by heavy manuring at planting would give them a better start and enable them to avoid the worst effects of Nematode attack.

On his return to Coorg, work on the Nematode fauna of the soil and methods of extracting worms from soil was continued and fresh inoculation experiments started. Studies of the possibilities of a hot water treatment of supplies were also undertaken.

General Observations.—The year saw the discovery of the presence of parasitic eelworms on coffee in a second area. They were found associated with the death of supplies in an estate on the lower slopes of the Bababudans. The distribution as at present known must be regarded as peculiar, comprising as it does an extensive area in South Coorg, a couple of isolated areas in North Coorg and an area in the Bababudans. The first and last areas have one factor in common in that both areas were bamboo country or verge on bamboo country. Enquiries

made at the Imperial Bureau of Agricultural Parasitology revealed that recent systematic work shows that morphologically, the coffee eelworm is similar to a species with a wide range of host plants of which species of bamboo provide several hosts. Work in Java tended to show, however, that the strain on bamboo was different from that on coffee as cross inoculations were unsuccessful. Whether the strain arose from a bamboo attacking strain must remain unproven.

Examination of soil in the dry weather shows that the worms have a marked seasonal fluctuation, and that during this part of the year it is extremely difficult to find worms in areas which during the rainy season show large numbers. Work during the latter part of the year was severely handicapped by lack of material. It has not yet been possible to decide how the worms survive the dry season. The methods of isolation in use only permit of the detection of living and active worms in the soil.

Inoculation Experiments.— So far no completely satisfactory inoculation experiments have been obtained. In the case of one plant inoculated in an observation box in which pieces of infected tissue were placed in contact with a healthy rootlet, infection of the rootlet was obtained and the presence of adult worms in the cortex was readily detected. The plant did not, however, develop typical symptoms during the course of an experiment lasting several months. Further work on this question is in progress.

Isolation of Worms from the Soil.—I am indebted to Dr. Goodey of the Imperial Bureau of Animal Parasitology for suggesting a modification of the funnel method, which we have used for isolating worms from roots, for isolating them from soil. This method has been found to work quite well and has been adopted for work on the soil population of worms. At the end of the year the Assistant was engaged on studying the possibility of devising a rough quantitative method to get at the comparative numbers of worms in the soil, both in different soils and at different times of the year. The results while as yet incomplete, offer some promise.

From preliminary experiments it appears that in infected soils, roughly 50 per cent of the worms present are of the parasitic type.

Manuring Treatment of Supplies in Eelworm Areas.—In view of the promising results obtained in Java by heavy manuring of supplies, experiments on this question were started in July 1933. The plants to be planted were subjected to a hot water treatment similar to that suggested in Java but unfortunately it proved to be too drastic. The experiments were restarted in September. The following manures were applied at planting—Sulphate of Ammonia, Superphosphate, Potash, Niciphos, Niciphos + Potash and a mixture commonly used in South Coorg for manuring, containing tobacco waste. Each of the experiments consisted of two plots to each treatment each containing ten nursery plants carefully selected for uniformity which were measured after planting. Measurements were taken at monthly intervals to January after which it was decided that such frequent measurements were not necessary. A full report of the results must await until next year, but so far no clear differences are appreciable.

The idea behind the experiment is two-fold. The Dutch workers found lower percentages of the three main mineral plant foods in eelworm attacked plants and their idea was to try and increase the intake of such materials in the hope that plants might become more resistant. However the lower percentage of minerals may really be an effect of the reduction of root absorbing area rather than a cause of susceptibility. At the same time, it was hoped that a plant well supplied with readily absorbable mineral food might make such strong and rapid growth that it could throw off the worst effects of the attack.

It is proposed to continue and extend this work during the coming year.

Hot Water Treatment of Supplies.—In order to prevent the conveyance of the pest from nurseries to the field, the Dutch workers recommended the use of hot water sterilization of seedlings to be planted out. They recommended, working with Robusta, that the plants be immersed in hot water at a temperature of 49C°. (121°F.) for ten minutes. This time and temperature was found too high for the Arabica plants with which we are working. A study was made of various times and temperatures to see what were the limits for Arabica seedlings of the type normally used for planting out. The following table gives the data obtained.

TABLE IX.

Hot Water Sterilization and its Effects on Arabica Seedlings.

Expt.	Temperature °C.		Time	Result
	Start	End	mins.	
1	60°	59·5°	3	Plants killed.
2	60°	59°	4	Do
3	55°	54·5°	5	Do
4	50°	49°	6	Do
5	50°	49°	8	Do
6	45°	44°	10	Do
7	45°	44°	15	7/10 survived.
8	41°	40°	15	Plants killed.
9	41°	39·5°	20	8/10 survived.
10	41°	40°	25	Plants killed.

Ten plants were subjected to each treatment and then planted out in beds in a small nursery and their behaviour recorded. There are certain inconsistencies in the results but it seems clear that the time and temperature recommended by the Dutch workers is too drastic a treatment for Arabica plants under the conditions prevailing in South Coorg.

In any case the treatment is unlikely to be of any great value as observations show that most of the soils where the eelworm problem has been severe are already infected. Consequently, the study was not continued to a consideration of the thermal death point of the worms.

Regeneration of damaged Root Tips.—Some preliminary experiments were made on the effect of cutting off the tips of young rootlets of plants planted in boxes with a glass side for observation purposes. Rootlets which had grown out and come in contact with the glass were cut and their fate observed. In only one case was there any sign of the production of a new rootlet in close proximity to the damaged tip. In nearly every case, the damaged root slowly died back for a considerable distance and any new roots which were produced were at points removed from the point of damage. While these experiments were only of a preliminary nature, they do suggest that root plants whose finer roots are inevitably damaged during transplanting bear a considerable amount of root

which will die back while the fresh roots are developing. It seems highly probable that these damaged roots offer a very suitable foothold for invading organisms such as the eelworms and add additional support to the suggestion that where eelworms are severe, it would be preferable to reduce the shock of transplanting as much as possible by the use of ball or basket plants.

During the Scientific Officer's home leave the Assistant carried on routine work at the Experiment Station and was responsible for the collection of the data on fruit set and on the spraying experiments, the maintenance of stock cultures of Leaf Disease and in general co-operation with the staff of the Experiment Station.

General Remarks. 1933 will long be remembered as an extremely unfavourable year for coffee in most districts. Blossom showers fell very generally towards the end of February and though the worst effects of such early showers were mitigated by the very regular rainfall from that time until the monsoon, this high hot weather rainfall had other serious effects. Diseases started early as a consequence of the showery weather of the months up to the monsoon, and leaf fall from Leaf Disease was noted as early as June. The S. W. monsoon was very wet and Black Rot took a considerable toll. In addition, in Mysore, a very severe attack of Die Back occurred and enormous amounts of young shoot and cropping wood was destroyed. As was noted earlier in the report, unsprayed areas at the Experiment Station showed as much as 23 per cent of the new wood destroyed by this disease by the end of September. The loss from the same cause of cropping shoots resulted in losses in crop which fell prematurely or remained and shrivelled up.

The S. W. monsoon continued longer than usual and October and November were also very wet and though in October trees seemed to be fairly free of Leaf Disease, they were carrying very much less leaf than usual, at least in sprayed areas. The later rains started a second attack of Leaf Disease and the trees entered the dry weather with rather more diseased leaf than usual. This is illustrated by data given in Table IV where the average percentage infection in the controls in February was about 40 per cent compared with about 25 per cent at the same time in 1933.

The result in terms of prospects for the 1934-35 season was a considerable reduction in bearing area and a poor development of bud. On the whole crops in 1933-34 were not large so that the damage was not as severe as it would have been if the plants had been attempting to carry a big crop.

Only a very few estates in Mysore had received any blossom showers before the end of the year and these were small in amount.

The year was notable for a very general experience of poorer results from spraying than have been obtained in previous years. The relative failure seems almost certainly to have been due to the early rains which resulted in an early start for Leaf Disease and in a rather slower growth of the new leaf and wood. Consequently, early spraying failed to cover a sufficient proportion of the new wood and late spraying failed to prevent development of quite a considerable amount of disease. It seems clear that years such as 1933 demand some modifications in the spraying programme and a recognition that early showers are formidable as a factor favouring early development of disease and greater difficulty in spraying efficiently.

The crop of 1933 contained a considerable amount of black and spotted beans but although conditions were so generally unfavourable, it is impossible to define the actual environmental conditions responsible for this serious defect in the harvested crop.

Diseases.—No new diseases were received for report during the year. A report of spray damage was investigated by the Assistant but no satisfactory explanation of the damage was arrived at. Spray damage is not unknown in other crops and is frequently associated with very wet conditions during spraying and it is along such lines that an explanation may perhaps be sought. It seems clear that Burgundy mixture, which was used in the damaged area, is a more dangerous spray than Bordeaux for coffee. Similar results have frequently been reported for other fruit crops. Other reports also show that such damage is very capricious in its appearance so that a sudden appearance on a small area may not necessarily be due to defects in the materials but to the existence of a certain complex of environmental factors which happens to favour spray injury.

Pests.—No new insect pests were received for report during the year. The extension of areas under Robusta coffee is beginning to show that Shot Hole Borer, *Xyleborus* spp. is by far the most serious enemy that this plant has to contend with. Specific control measures have not yet been found and the only method of mitigating the damage is to encourage the formation of secondary growth as early as possible. Loss of secondaries is serious enough, but it is not as serious as the destruction of primaries which are irreplaceable. Bug pests on aerial parts of plants were not serious in 1933 as they are not encouraged by the wet conditions characteristic of the year.

Correspondence and Publications.—Two hundred and thirteen letters were despatched during the year. Enquiries show a slight falling off from previous years; as in previous years most enquiries deal with spraying and related questions.

No new publications were prepared during the year, but both the bulletin on spraying prepared in co-operation with Mr. M. J. Narasimhan, Mycologist and Mr. K. H. Srinivasan, Assistant Director of Agriculture, Mysore State and the bulletin on Nematode Worms were actually published during this year. A short note on the disease situation in the monsoon of 1933 was prepared in co-operation with Mr. M. J. Narasimhan and Mr. K. H. Srinivasan and this was published both as a Circular of the Coffee Experiment Station and in the Planter's Chronicle.

During the course of long leave, the Scientific Officer visited the Imperial Mycological Institute. The Imperial Entomological Institute, the Imperial Bureau of Agricultural Parasitology, and the offices of Messrs. Rouse & Co., Messrs. Leslie and Anderson, Messrs. Peirce Leslie, The Overseas Potash Supply Co., and Messrs. Drake and Fletcher, in connection with enquiries bearing on aspects of the work on coffee. It is a pleasure to acknowledge the assistance given me by the officers and representatives of these organizations and firms.

Acknowledgments.—It gives me great pleasure to express once again my very great appreciation of the continued cordial advice and assistance which has been accorded me at all times by Dr. Coleman and his staff both at Bangalore and at the Coffee Experiment Station. It is with feelings of great regret that it was learnt at the end of the year that Dr. Coleman's health necessitated

his retirement. The scientific work on coffee reported in this and all previous reports owes a tremendous debt of gratitude to his inspiration and advice.

The work of the Assistant has been very satisfactory during the year, but has unfortunately suffered a certain amount of interruption in the latter part of the year from malaria. Work at Sidapur was also somewhat handicapped by absence of Nematode material in the dry weather but substantial progress in the development of technical methods of investigation has been made.

Finally, I have great pleasure in recording my thanks to the many planters who have assisted me in many ways during the past year.

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